

CLAIMS

WE CLAIM:

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1. A process for creating a broadly tunable Distributed Bragg Reflector (DBR) structure with a low spontaneous recombination rate at operating temperatures

6 comprising the steps of:

creating a first cladding layer of a first conductivity type;

creating an optical waveguide disposed on top of said first cladding layer

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comprising the steps of creating one or more hole confinement regions and

creating one or more electron confinement regions wherein energy barriers of greater than the thermal energy, kT , separate adjacent confinement regions;

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creating a second cladding layer of a second conductivity type disposed on top of said optical waveguide.

2. The process of claim 1 further comprising the step of creating a grating layer.

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3. The process of claim 1 wherein:

a conduction band energy barrier greater than the thermal energy, kT , is created by establishing an effective conduction band offset between adjacent confinement regions;

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a valence band energy barrier greater than the thermal energy, kT , is created by establishing an effective valence band offset between adjacent confinement regions;

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the band gap of said first cladding layer and the band gap of said second cladding layer are greater than the effective band gaps of said hole confinement regions;

the band gap of said first cladding layer and the band gap of said second cladding layer are greater than the effective band gaps of said electron confinement regions;

a first cladding layer conduction band energy barrier greater than the thermal energy, kT , is created by establishing an effective conduction band offset between the conduction band of said first cladding layer and the conduction band of the adjacent confinement layer;

a second cladding layer conduction band energy barrier greater than the thermal energy, kT , is created by establishing an effective conduction band offset between the conduction band of said second cladding layer and the conduction band of the adjacent confinement layer;

a first cladding layer valence band energy barrier greater than the thermal energy, kT , is created by establishing an effective valence band offset between the valence band of said first cladding layer and the valence band of the adjacent confinement layer; and

a second cladding layer valence band energy barrier greater than the thermal energy, kT , is created by establishing an effective valence band offset between the valence band of said second cladding layer and the valence band of the adjacent confinement layer

4. The process of claim 1 wherein said first cladding layer comprises an n-type
45 cladding layer and said second cladding layer comprises a p-type cladding layer.
5. The process of claim 1 wherein said first cladding layer comprises a p-type
cladding layer and said second cladding layer comprises an n-type cladding layer.
- 48 6. The process of claim 3 wherein a valence band energy barrier greater than twice
the thermal energy, $2kT$, is created by establishing an effective valence band offset
between adjacent confinement regions.
- 51 7. The process of claim 3 wherein a conduction band energy barrier greater than
twice the thermal energy, $2kT$, is created by establishing an effective conduction band
offset between adjacent confinement regions.
- 54 8. The process of claim 3 wherein a cladding conduction band energy barrier equal
to greater than twice the thermal energy, $2kT$, is created by establishing an effective
conduction band offset between the conduction band of said first cladding layer and the
57 conduction band of the adjacent confinement layer.
9. The process of claim 3 wherein a cladding conduction band energy barrier equal
to greater than twice the thermal energy, $2kT$, is created by establishing an effective
60 conduction band offset between the conduction band of said second cladding layer and
the conduction band of an adjacent confinement layer.
10. The process of claim 3 wherein a cladding valence band energy barrier equal to
63 greater than twice the thermal energy, $2kT$, is created by establishing an effective valence
band offset between the valence band of said first cladding layer and the valence band of
the adjacent confinement layer.

- 66 11. The process of claim 3 wherein a cladding valence band energy barrier equal to
greater than twice the thermal energy, $2kT$, is created by establishing an effective valence
band offset between the valence band of said second cladding layer and the valence band
69 of the adjacent confinement layer.
12. The process of claim 3 wherein the step of creating said broadly tunable DBR
comprises creating one or more graded layers.
- 72 13. The process of claim 12 wherein said first cladding layer comprises one or more
graded layers.
14. The process of claim 12 wherein said second cladding layer comprises one or
75 more graded layers.
15. The process of claim 12 wherein said optical waveguide comprises one or more
graded layers.
- 78 16. The process of claim 12 wherein said graded layer varies in composition across
the thickness of said optical waveguide.
17. The process of claim 12 wherein said graded layer varies in energy band structure
81 across the thickness of said DBR.
18. The process of claim 12 wherein said graded layer varies in composition across
the breadth of said DBR.
- 84 19. The process of claim 12 wherein said graded layer varies in energy band structure
across the breadth of said DBR.
20. The process of claim 3 wherein the thickness of said optical waveguide is selected
87 to support a single optical mode.

21. The process of claim 3 wherein said optical waveguide comprises one electron
confinement region and one hole confinement region wherein said electron confinement
92 layer comprises a layer of material of uniform composition and said hole confinement
layer comprises a layer of material of uniform composition.

22. The process of claim 3 wherein said optical waveguide comprises one electron
93 confinement region and one hole confinement region wherein said electron confinement
layer comprises a layer of material of uniform energy band structure and said hole
confinement layer comprises a layer of material of uniform energy band structure.

96 23. The process of claim 3 wherein adjacent confinement regions comprise layers of
lattice matched materials.

24. The process of claim 23 wherein said electron confinement regions comprise
99 InGaAsP material lattice matched to InP and said hole confinement regions comprise
InGaAlAs material lattice matched to InP.

25. The process of claim 23 wherein said electron confinement regions comprise
102 InGaAsSb material lattice matched to InP and said hole confinement regions comprise
InGaAlAsSb material lattice matched to InP.

26. The process of claim 3 wherein the thickness of said electron confinement regions
105 is greater than the thickness of said hole confinement regions.

27. The process of claim 3 wherein the effective conduction band offset between
adjacent confinement regions is greater than the effective valence band offset between
108 adjacent confinement regions.

28. The process of claim 3 further comprising the step of creating one or more graded
layers disposed between said optical waveguide and said first cladding layer.

29. The process of claim 3 further comprising the step of creating one or more graded layers disposed between said optical waveguide and said second cladding layer.

30. The process of claim 3 further comprising the step of creating one or more graded layers disposed between adjacent confinement regions.

31. The process of claim 1 further comprising the step of creating one or more additional cladding layers.

32. The process of claim 1 wherein said energy barriers are created by band gap tilting wherein:

said optical waveguide comprises a layer of graded material wherein the energy level of the lowest conduction band of said waveguide increases across the thickness of said waveguide, the energy level of the highest valence band of said waveguide increases across the thickness of said waveguide and the energy band gap of said waveguide varies across the thickness of said waveguide;

the changes in said energy levels creates an electron confinement region in said optical waveguide comprising a region wherein said energy level of the lowest conduction band and the adjacent cladding layer forms a local minimum in the conduction band;

the changes in said energy levels creates a hole confinement region in said optical waveguide comprising a region wherein said energy level of the highest valence band and the adjacent cladding layer forms a local maximum in the valence band;

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the average band gap of said optical waveguide is greater than or equal to the carrier concentration in said optical waveguide divided by twice the thickness of said optical waveguide.

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33. The process of claim 32 wherein:

said optical waveguide comprises one or more layers of material wherein the energy band structure varies across the breadth of said waveguide.

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34. The process of claim 32 wherein said conduction band and said valence band of said graded layer comprise sloped, stepped or curved profiles across the thickness of said optical waveguide.

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35. The process of claim 32 wherein the materials composition of said graded layer comprise sloped, stepped or curved profiles across the thickness of said optical waveguide.

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36. The process of claim 32 wherein said conduction band and said valence band of said graded layer comprise sloped, stepped or curved profiles across the breadth of said optical waveguide.

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37. The process of claim 32 wherein the materials composition of said graded layer comprise sloped, stepped or curved profiles across the breadth of said optical waveguide.

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